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# UMass Amherst Continuous Commissioning Proposal: Potential Costs, Cost Savings and Required Resources

Katrina Spade

*University of Massachusetts - Amherst*

Jason Burbank

*University of Massachusetts - Amherst*

Katherine McCusker

*University of Massachusetts - Amherst*

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# UMASS AMHERST CONTINUOUS COMMISSIONING PROPOSAL

Potential costs, cost savings, and required resources





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## Primary Authors

Jason Burbank, Energy Engineer  
Katherine McCusker, Green Building Researcher  
Katrina Spade, Green Building Researcher



The UMass Amherst Continuous Commissioning Proposal was prepared by Physical Plant and Facilities Planning staff under the supervision of Pat Daly, Director of Physical Plant. It outlines a targeted approach for improving the performance and efficiency of existing buildings on campus. The goal of the proposal is to reduce unnecessary energy use on campus by systematically checking and adjusting controls and systems to optimize their efficiency, as well as ensuring that buildings satisfy their programmatic needs.

The proposal recognizes the great potential for reducing the energy costs and carbon footprint of our existing buildings, as well as the need for improvements in occupant comfort and indoor air quality. To that end, the goals of the UMass Commissioning-Commissioning Plan are **energy cost savings, improved occupant comfort, and reductions in GHG emissions.**

Initial estimates suggest that the payback for implementing the UMass Amherst Continuous Commissioning Plan will be approximately 3 years. (See page 19 for details on the estimated simple payback.)

### What is commissioning?

Building commissioning (Cx) is a method of risk reduction for new construction and major renovation projects to ensure that building systems meet their design intent. As long as the design intent is clear and accurate, a commissioned building should effectively serve the needs of its occupants and owner. This systematic process typically includes:

- HVAC
- lighting
- controls
- envelope
- hot water
- security
- fire, life and safety systems

The term commissioning comes from shipbuilding. A commissioned ship is one that has been thoroughly inspected and tested and is deemed ready for service.

### What is retro-commissioning?

When the commissioning process is applied to existing buildings to optimize performance, it is called retro-commissioning (RCx). Once a building has been occupied, its design intent can be stated with much more precision than at initial design. Operators have learned about the actual building behavior, and adjustments and minor repairs will often greatly benefit the building's service to its occupants.

RCx typically focuses on identifying low-cost operational and maintenance improvements, rather than relying on major equipment replacement. Specifically, energy-using components are systematically inspected and tested, such as:

- HVAC
- lighting
- related controls
- envelope\*

The RCx process is a whole building tune-up and typically results in improved indoor air quality, occupant comfort, and energy efficiency.

\* Hot water systems aren't typically part of the retro-commissioning process because they involve such a simple conversion of steam to hot water and have little room for improved efficiency. Fire and safety systems are not typically part of the process because they are not energy intensive, and they are checked regularly by fire and safety inspectors.

### What is continuous-commissioning?

When buildings are commissioned on an ongoing basis, it is called continuous-commissioning (CCx). After about 5-7 years, a building which has been commissioned will need a tune-up. Continuous commissioning means that the commitment to optimize building performance is long term and ongoing.

#### Continuous-Commissioning in a nutshell:

A focused systematic review of air conditioning & heating systems and their sequences of operations in an attempt to save as much energy as reasonably possible without overly affecting operations.

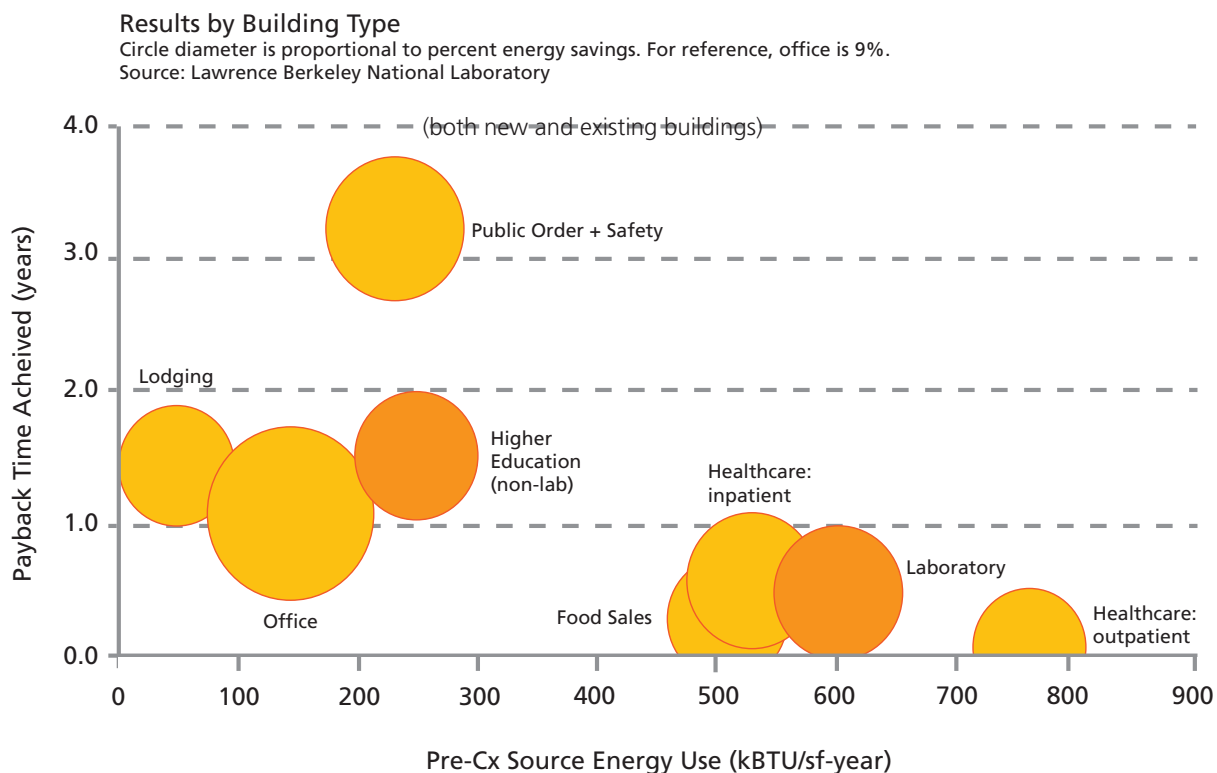


### Why commission continuously?

Three reasons: cost savings, occupant comfort, and greenhouse gas emission reductions. Buildings that are retro-commissioned have a median cost savings of \$0.29 per sf per year.<sup>1</sup> Recently, Harvard completed their efforts to retro-commission the Laboratory for Integrated Science and Engineering (LISE) laboratory building and showed an annual savings of over \$520,000 and a reduction of 800 metric tons of carbon dioxide equivalent (MTCDE).<sup>2</sup> (See Harvard Case Study page 26.) Making the commitment to retro-commission on an on going basis (i.e. continuous commissioning) means that the annual savings will persist year after year.

### Is commissioning cost-effective?

Yes. A 2009 Lawrence Berkeley National Laboratory study identified untapped potential in building commissioning. The study looked at **399 new and existing building commissioning projects**. The chart below shows the average payback time in years for all of the buildings in the study. Of particular relevance to the UMass Amherst campus are the paybacks for laboratories and for non-lab higher education buildings.



### Is continuous-commissioning cost-effective?

Yes. The same study analyzed the average cost and payback for commissioning existing buildings (retro-commissioning) by a third party firm and found:<sup>3</sup>

- 1.1 years median payback time
- 16% median whole building energy savings for existing buildings
- \$0.30 per sf median normalized cost

<sup>1</sup> *Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions*, Lawrence Berkeley National Laboratories, 2009, page 1 .

<sup>2</sup> Harvard University, 2011.

<sup>3</sup> *Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions*, Lawrence Berkeley National Laboratories, 2009, page 1 .

### Potential energy cost savings for the UMass Amherst Campus

According to the Lawrence Berkeley National Laboratory study, retro-commissioning of existing buildings produced a median cost savings of \$0.29 per sf per year.<sup>4</sup> Applying this metric to the 10.8 million square feet of existing buildings on the UMass Amherst Campus produces an estimated energy cost savings of \$3.1 million dollars annually.

However, not all buildings are ideal candidates. This proposal includes those buildings which would benefit the most from a continuous-commissioning process, based on criteria such as age, HVAC system type, size and condition.

### Case Study: UConn Unveils Campus-Wide Retro-Commissioning Project

The University of Connecticut has begun implementing recommended energy conservation measures at a dozen campus buildings as part of phase one of its campus-wide continuous commissioning project. The University's Smart Building Smart Grid Workgroup, driven by eight School of Engineering faculty members, will use one of the retro-commissioned buildings as a test bed for research that will also raise campus awareness about enhanced sensors, controls and fault detection for building systems. The continuous commissioning project is expected to improve the energy efficiency of 34 campus buildings, saving \$500,000 in energy costs and cutting 3,000 tons of greenhouse gas emissions annually.

Source: University of Connecticut, June 2011

### What are the costs associated with continuous commissioning?

When done in-house, the costs are largely time and labor; there are relatively few materials or capital equipment costs associated with CCx. (See page 18 for details on UMass Amherst Continuous Commissioning cost estimates.)

### In-house Team vs. Third Party Hire

By creating an in-house commissioning team, the University will achieve continuous cost-savings while it increases the knowledge-base of its operations and maintenance staff. Although it is tempting and seemingly simpler to use a third party firm to commission our buildings, it is critical that information learned about campus buildings during the retro-commissioning process remains on site. This knowledge is a resource, and it would be a missed opportunity to let it go elsewhere. In-house continuous-commissioning - the complete and ongoing understanding of our buildings' operations - will benefit the long term health of the University.

### Continuous commissioning for the UMass Campus

The high potential for cost savings, coupled with the urgency of reducing energy use and greenhouse gas emissions, make the formation of a UMass continuous-commissioning program truly vital. Continuous-commissioning is a sound, practical, and cost-effective solution for the UMass campus.

<sup>4</sup> *Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions*, Lawrence Berkeley National Laboratories, 2009, page 1 .





Since July 2010, a pilot team has been working on the Integrated Science Building (2009) and the Studio Arts Building (2008) to test the efficacy of a continuous-commissioning plan for the UMass Amherst campus. The goal has been to better understand the cost of in-house continuous-commissioning and the magnitude of energy savings that can be gained.

The pilot project demonstrated significant energy savings during the 6 month period. Most compelling is the 16% energy savings for the ISB, whose FY2011 energy costs totalled more than \$850,000. Equally compelling is the fact that less than half of what would normally be considered retro-commissioning was completed during the pilot project.

### **Pilot Team**

Jason Burbank, Energy Engineer, Physical Plant (5 hrs/wk)

Katherine McCusker, Graduate Student, Green Building Researcher, Facilities Planning (20 hrs/wk)

Samantha Willis, Undergraduate Student, Sustainability Initiative, Physical Plant (10 hrs/wk)

## Retro-Commissioning Pilot Team

The pilot team was made up of one senior level energy engineer and two UMass Amherst students (one grad, one undergrad) from the Green Building and the Civil/Environmental Engineering programs, respectively. The energy engineer supervised and trained the students on many of the initial commissioning tasks such as creating a building spreadsheet to capture basic operations data and building schedules, reading HVAC construction drawings, using the building automation system software (Metasys) to track real-time data, and surveying building occupants about comfort and other building performance issues.

Initially conceived of as a task group to find energy savings for the Studio Arts Building to meet the LEED for Existing Buildings (EBOM) energy efficiency prerequisite, the team soon decided to go after savings in the Integrated Science Building as well. The initial pilot project results - described in the next few pages - are evidence that the savings reported by retro-commissioning studies (primarily the Lawrence Berkeley Laboratory Study) could be achieved for the campus.

Since the pilot project, the pilot team has continued to track the energy usage of both buildings, and has been glad to see the savings persisting. The pilot team is now studying the University's first LEED certified facility - the George N. Parks Minuteman Marching Band Building - developing a template for a Building Operations Manual, and developing a means to weather normalize building energy data using weather data collected on campus. The pilot team has also conducted research on what is done at other campuses, and created initial job descriptions and a task list for an in-house Continuous Commissioning Team. The pilot team estimates that it accomplished 15-20% of the full continuous commissioning protocol (see pages 22-23 of this report) on the two pilot project buildings.

<b>Pilot Project: July-December 2011</b>	
ISB Energy Saving FY11 vs FY12	16%
SAB Energy Saving FY11 vs FY12	6%
ISB Cost Savings FY11 vs FY12	16%
SAB Cost Savings FY11 vs FY12	14%
ISB Electric Cost Savings	\$25,877
SAB Electric Cost Savings	\$6,493
Total Electric Energy Cost Savings	\$32,370
ISB Steam Cost Savings	\$41,818
SAB Steam Cost Savings	\$136
Total Steam Energy Cost Savings	\$41,954
ISB Electric Chiller Savings	\$2,446
SAB Electric Chiller Savings	\$0
Total Electric Chillers Energy Cost Savings	\$2,446
Total ISB Energy Cost Savings	\$70,141
Total SAB Energy Cost Savings	\$6,629
<b>Total Project Energy Cost Savings</b>	<b>\$76,770</b>

### Integrated Science Building

- Year Completed: 2009
- Square Feet: 188,447 gross
- Annual energy cost FY11: \$869,951
- Electricity = 4,455,222 kWh
- Steam = 38,426,513 lbs
- Chilled Water = 602,557 kWh
- Total kBtu = 61,945,362
- kBtu per SF = 329 kBtu/sq.ft.

### Studio Arts Building

- Year Completed: 2008
- Square Feet: 52,881 gross
- Annual energy cost FY11: \$88,413
- Electricity = 829,044 kWh
- Steam = 1,900,568 lbs
- Chilled Water = 114,151 kWh
- Total kBtu = 5,410,676
- kBtu per SF = 102 kBtu/sq.ft.



### Retro-Commissioning Pilot Project: the Integrated Science Building (ISB)

The Integrated Science Building (ISB) was built in 2009 to integrate life and chemical sciences on campus. It includes 85,000 square feet of modern classrooms and laboratories for basic and advanced courses in chemistry, biochemistry, and biology, a 300-seat auditorium, and flexible research laboratories for life sciences research teams. The ISB was chosen for the pilot project in part because the biggest “bang for the buck” is those buildings that have high energy costs, such as lab buildings. In 2010-2011, the ISB used 5 million kWh and 38.4 million lbs of steam for a combined cost of \$869,951. Its Energy Use Intensity is 329 kBtu/sq.ft.

The ISB had not been retro-commissioned since it opened in January of 2009. Its mechanical systems were commissioned as part of the construction process, and it was publicized as a high performance building. The building’s design includes many strategies whose purpose is energy reduction: radiant perimeter ceiling panels, motion detectors for lighting fixtures, and a high efficiency, state-of-the-art heat exchange system for heating and ventilation.



As a laboratory building, it is expected that the ISB will have relatively high energy costs. High-tech buildings have a number of characteristics that cause them to have high energy-costs, including around-the-clock operation and high ventilation rates. The ISB is about average when it comes to energy use compared to the nationwide average for laboratory buildings, but does not qualify for the LEED for Existing Buildings (EBOM) energy prerequisite. Currently, LEED certification is the industry standard to evaluate sustainable buildings. To attain LEED Certification buildings must demonstrate that they use at least 19% less energy than other buildings of the same type.

The fact that the ISB is not actually “high performing” is unfortunate from a cost perspective, and it contradicts the University’s commitment to sustainability. The pilot project team suspected that significant energy cost savings could be found by optimizing controls and ensuring that all energy-using equipment was working properly, and they began to retro-commission the building.

The team worked on the building off and on for a period of six months. At the end of that time they had realized a savings of \$70,141 over the previous year’s 6-month period, primarily by reducing ventilation rates during unoccupied hours and optimizing air temperature setpoints. The cost savings totaled 16% of the building’s energy costs, aligning closely with the Lawrence Berkeley National Laboratories 2009 study. Furthermore, due to the time constraints of the pilot team, they estimated that they completed under half of the energy-optimizing measures that would be done in a comprehensive retro-commissioning effort.

## Retro-Commissioning Pilot Project: The Studio Arts Building (SAB)

The Studio Arts Building (SAB) is a classroom and studio art building completed in 2008. It houses studios workshops for metal and woodwork, printmaking, photography, ceramics, sculpture, painting & drawing. The SAB is touted as one of the “green” buildings on campus because of energy-saving strategies such as occupancy sensors for lighting and ventilation, sun-shading devices to optimize the sun’s light and heat during different times of the year, and energy recovery wheels in the ventilation system.

In 2009, the UMass Green Building Committee decided to look at the SAB as a pilot for LEED for Existing Buildings (EBOM) certification on campus. In order to attain LEED Certification under the EBOM system, buildings must demonstrate that they use at least 19% less energy than other buildings of the same type. When compared to the national average for higher education buildings of its type, the SAB uses 8% less energy, which is quite good for a building that has a robust ventilation system, but it does not meet the basic LEED energy prerequisite. In 2010-2011, the SAB used 943,000 kWh and 1.9 million lbs of steam for a combined cost of \$88,413. Its Energy Use Intensity was 102 kBtu/sq.ft. The pilot team agreed to retro-commission the building to see whether they could get the SAB to qualify for LEED-EBOM.



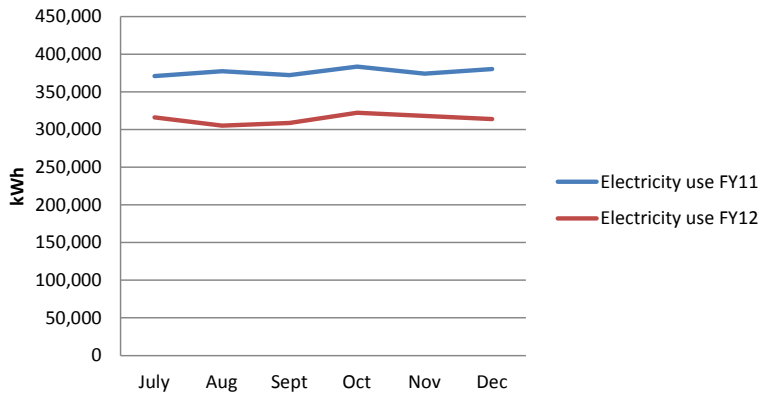
The RCx Pilot Team discovered that the building suffered from major air handler control problems which led to constant operator overrides in an attempt to satisfy occupant needs. After adjusting the computerized control sequence, which fixed the air handler issue, the team made additional efficiency improvements to the building. Thus far, the SAB has achieved 6% energy savings.

Because the building has been chosen to attempt LEED-EBOM certification, the pilot team will continue to look for energy savings. However, the team will have to more than double the current savings for the SAB to meet the energy prerequisite for LEED certification.



## Initial energy reductions: Integrated Science Building / July-December 2011

### ISB Electricity Use FY11 vs FY12



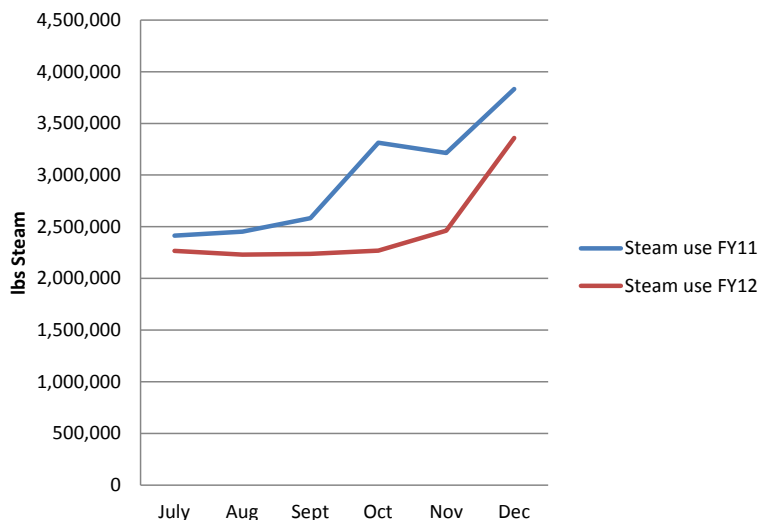
#### ISB Electric Use (6 mo. period)

	kWh	Costs*
FY11	2,258,203	\$156,673
FY12	1,884,299	\$130,796
Diff.	373,904	\$25,877

Yearly projected savings for FY2012= \$51,754

\*using blended electrical rates from FY2011

### ISB Steam Use FY11 vs FY12



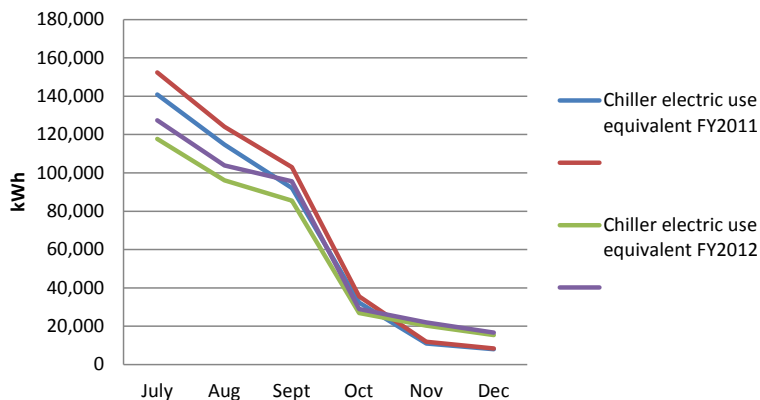
#### ISB Steam Use (6 mo. period)

	lbs	Costs*
FY11	17,810,606	\$249,348
FY12	14,823,577	\$207,530
Diff	2,987,029	\$41,818

Yearly projected savings for FY2012= \$83,637

\*\$14/1000 lbs

### ISB Chilled Water Use FY11 vs FY12



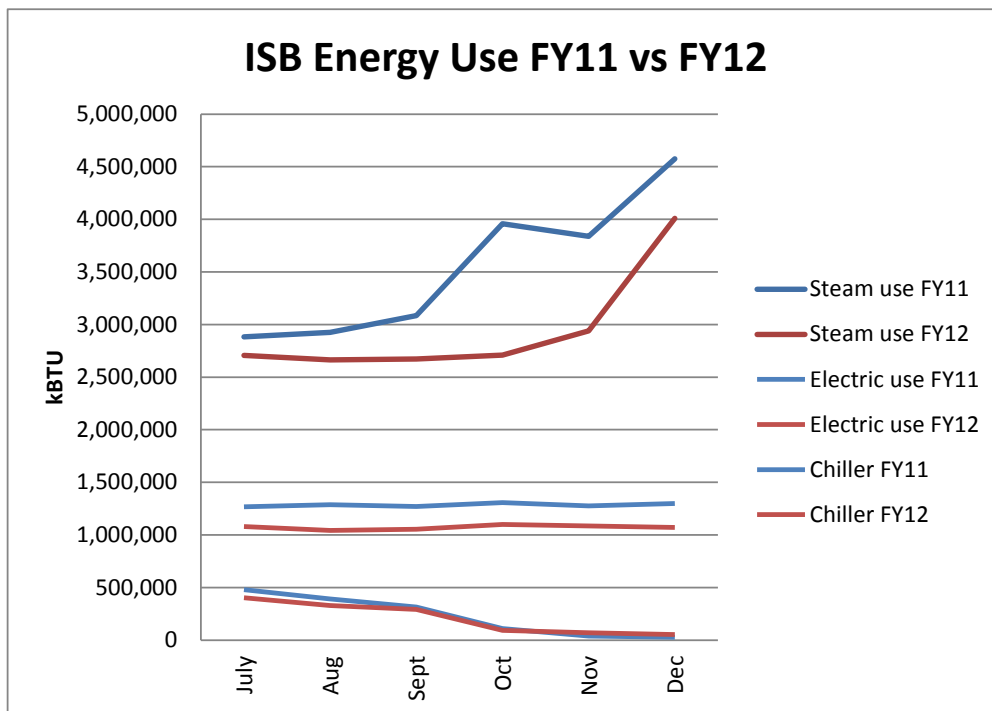
#### ISB Electric Chiller (6 mo. period)

	kWh	Costs*
FY11	399,219	\$26,269
FY12	362,050	\$23,823
Diff.	37,169	\$2,446

Yearly projected savings for FY2012= \$4,891

\*using consistent kWh rate

Please note: there are some issues with the chilled water data for the ISB, which the pilot team is working on now.



#### ISB Energy Costs & Anticipated Savings:

Costs FY11 \$869,951	Pilot Savings (6mo) \$70,141	Anticipated Savings FY12 \$140,282	% Savings in \$ 16.13%
kBtu FY11 61,945,362	Pilot Savings (6mo) 4,969,505	Anticipated Savings FY12 9,939,010	% Savings in kBtu 16.04%

The first round of energy savings at the ISB were obtained by:

- using teaching lab occupancy schedules
- optimizing static pressure setpoints for all building supply and exhaust/return fans
- optimizing air handler discharge air setpoints to dehumidify only when required
- reducing fume hood exhaust levels nights and weekends (still subject to room occupancy sensors)
- reducing static pressures except when labs are occupied
- drastically reducing office wing fan speeds overnight to save fan horsepower, but maintained required building pressure and humidity levels

The bulk of savings were accrued from reduced fan horsepower, particularly during unoccupied periods, with chilled water and steam savings also arising from optimized supply air temperature setpoints.

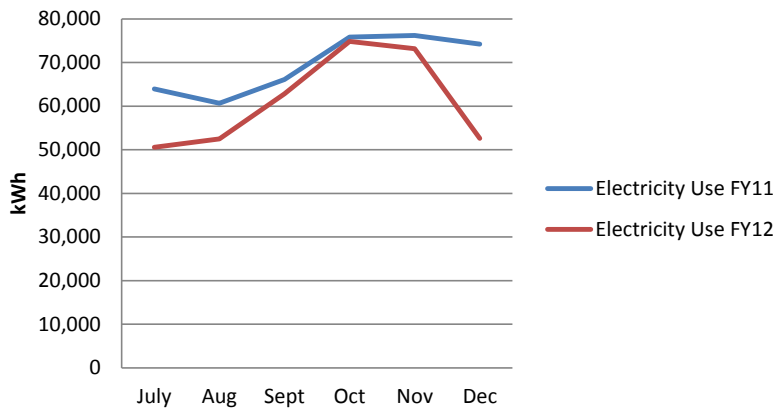
Significant further savings can be achieved by automating static pressure optimization, demand controlled ventilation in the office wing, making use of lab shutdown mode during extended unoccupied times, and improved programming of heat wheel control as well as improved lighting control.

Although steam savings this year have been large in the winter months, these are predominantly due to much warmer weather this year compared to last. Only the steam savings appearing in the summer and fall, due to reduced reheat requirements, are attributed to this retro-commissioning effort.



## Initial energy reductions: Studio Arts Building / July - December 2011

### SAB Electricity Use FY11 vs FY12



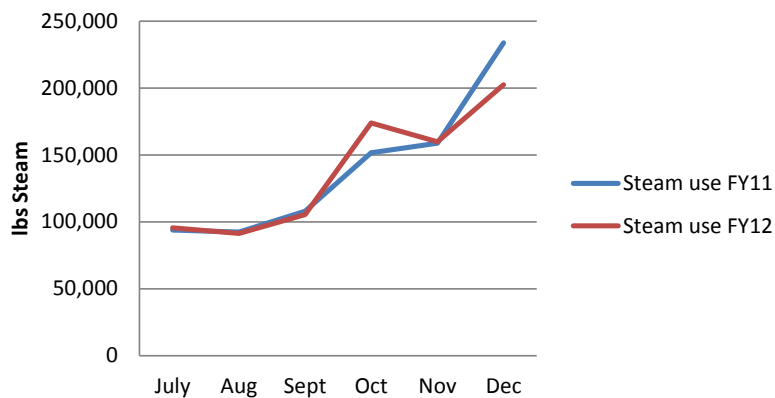
#### SAB Electric Use (6 mo. period)

	kW	Costs*
FY11	417,010	\$28,852
FY12	366,590	\$22,359
Difference	50,420	\$6,493

Yearly projected savings for FY2012= \$12,986

\*using blended electrical rates from FY2011

### SAB Steam Use FY11 vs FY12



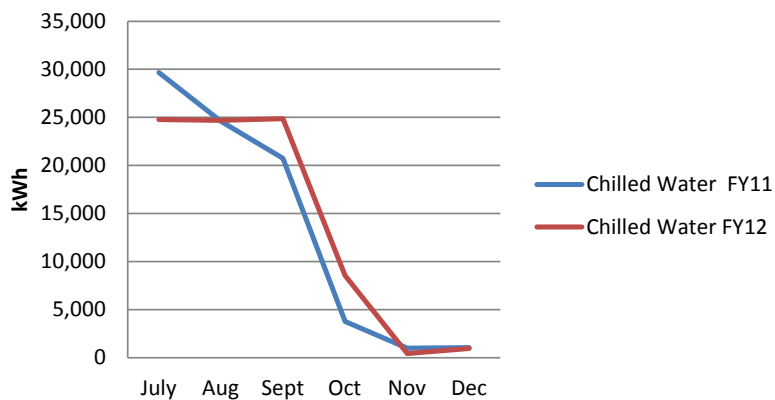
#### SAB Steam Use (6 mo. period)

	lbs	Costs*
FY11	838,281	\$11,736
FY12	828,567	\$11,600
Difference	9,714	\$136

Yearly projected savings for FY2012= \$272

\*\$14/1000 lbs

### SAB Chilled Water Use FY11 vs FY12



#### SAB Electric Chiller (6 mo. period)

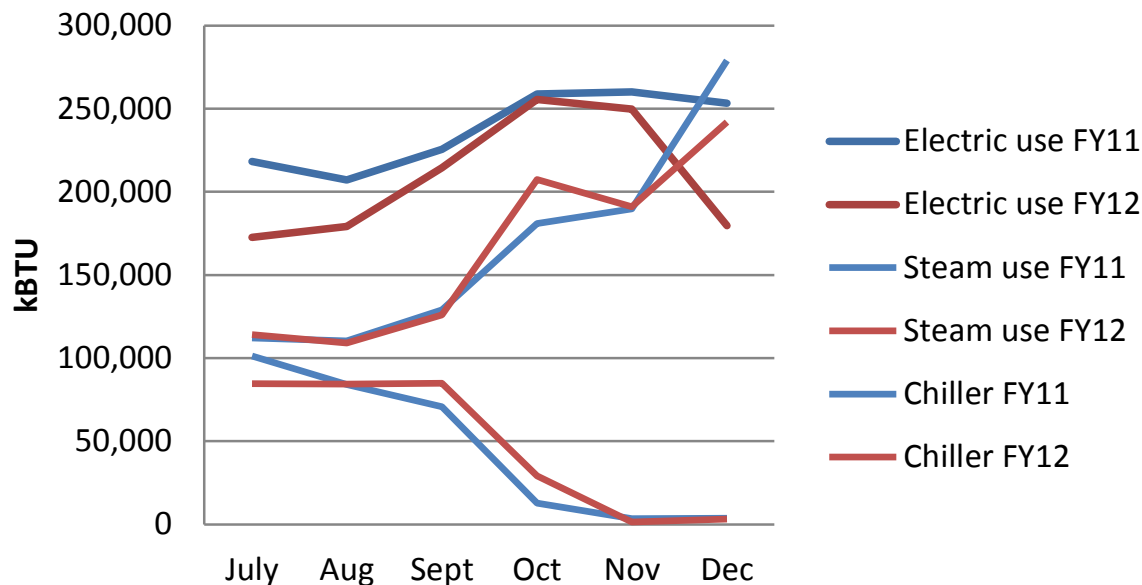
	kWh	Costs
FY11	80,793	\$5,316
FY12	84,290	\$5,546
Difference	-3,496	-\$230

Yearly projected savings for FY2012= \$0

\*using consistent kWh rate



## SAB Energy Use FY11 vs FY12



### SAB Energy Costs & Anticipated Savings:

Costs FY11	Pilot Savings (6mo)	Anticipated Savings FY12	% Savings in \$
\$88,413	\$6,399	\$12,798	14.47%
kBtu FY11	Pilot Savings (6mo)	Anticipated Savings FY12	% Savings in kBtu
5,410,676	171,748	343,497	6.35%

Investigations into HVAC operations at the SAB quickly revealed major air handler control problems, leading to constant operator overrides in an attempt to satisfy occupant needs. These were finally addressed by November, when improvements in static pressure optimization were also made. During the winter break some air handlers were shut down overnight. This was not deemed feasible during the semester due to the heavy after hours use of the building. The shortage of operating time under improved control make precise prediction of annual savings difficult, but November and December electrical savings should be retained in the future as well as some portion of the steam savings. The 40% electrical savings in December is roughly indicative of potential in December/January and to a lesser degree in summer months.

Significant further savings can be achieved by automating static pressure optimization, pinning air handler operation to actual building occupancy after hours, and adjusting unoccupied minimum ventilation rates in the spaces.





The pilot project has demonstrated that there are real, deep energy savings to be made if we allocate resources towards a continuous commissioning plan for the UMass Amherst campus.

The next step is to create a dedicated commissioning team of qualified professionals who will manage the systematic review and commissioning of existing campus buildings.

## Continuous Commissioning Team

The following continuous commissioning team configuration is based on numerous interviews of university commissioning teams as well as on the working knowledge of the pilot project team. With the exception of the graduate students, all team members will be dedicated to the continuous commissioning of campus buildings full time.

- 1 Lead Project Manager (Energy Engineer) - 1 new hire
  - 1 Project Manager (Energy Engineer) - 1 new hire
  - 1 Mechanical Engineer/Lighting specialist - 1 new hire
  - 1 Building Automation System Programmer - 1 new hire
  - 1 Control Technician - 1 new hire
  - 1 Electrician - 1 new hire
  - 1 Administrative Assistant - 1 new hire
- 
- RCx Coordinator (grad student)
  - 4 Engineering Grad students for special studies (optional)

Training UMass Amherst students to work on the continuous commissioning team aligns with the goals of the University to be a living laboratory, prepare the workforce of the future, and contribute to energy-focused research. The pilot project has also demonstrated that involving students in the project - especially those from the University's civil engineering and green building programs - is an effective way to maximize resources.

## Team Role

The team will choose 3-4 existing buildings per year to retro-commission, based on parameters such as building age, gross square footage, and the campus master plan. In addition, the team will also contribute to the commissioning of major new building projects, sitting in on commissioning meetings and shadowing the third party commissioning agents during new construction commissioning. This will promote the continuity of energy efficiency goals and technical expertise, keeping the knowledge of building operations within the UMass Amherst community.

The first 6 months will be the training phase in which the DDC programmer works closely with Johnson Controls staff to learn Metasys, and the two Project Managers work closely with campus energy engineers to learn campus systems and develop a repeatable continuous-commissioning process.

## Buildings

The following is a suggested list of buildings to tackle first, based on the current knowledge of campus energy engineers.

- Conte Polymer Science Building
- Integrated Science Building
- Studio Arts Building
- Recreation Center



### Approximate Cost<sup>1</sup>

The majority of the cost for the continuous commissioning team will be salaries and benefits (assuming all state funded positions). An additional annual cost has been added for operations which would include basic equipment, IT software & hardware, and small scale building upgrades such as occupancy sensors and duct repair. The E+ program could be a source for larger scale building upgrades and energy focused projects with a payback of under 7 years. Any major projects or renovations that were discovered by the team would be directed to the Facilities Planning Department for review.

- 1 Lead Project Manager (Energy Engineer - Direct Report to Physical Plant Director)  
@ \$92,000 salary + \$2,245 benefits = \$94,245
- 1 Project Manager (Energy Engineer)  
@ \$88,000 salary + \$2,147 benefits = \$90,147
- 1 Mechanical Engineer/Lighting specialist  
@ \$77,000 salary + \$1,879 benefits = \$78,879
- 1 Building Automation System Programmer  
@ \$49,000 salary + \$1,196 benefits = \$50,196
- 1 Control Technician  
@ \$56,000 salary + \$1,366 benefits = \$57,366
- 1 Electrician  
@ \$56,000 salary + \$1,366 benefits = \$57,366
- 1 Administrative Assistant  
@ \$35,000 salary + \$854 benefits = \$35,854

### Additional Costs (not estimated)

- Coordinator (grad student)
- 4 Engineering grad students for special studies (optional)

**Total Approximate Cost for Dedicated Team = \$464,053/yr**

**Total Approximate Operations Costs = \$100,000/yr**

**Total Approximate Annual Costs = \$564,053/yr**

The continuous commissioning team will track and report all savings gained by their work and by projects that they have referred to the physical plant and facilities planning departments. This will allow those departments and the University administration to easily understand the value of the continuous commissioning team, and to convey stories of energy cost savings to the public.

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<sup>1</sup> Based on September 2011 Bureau of Labor Statistics Employer Cost for Employee Compensation and University of Massachusetts average project manager salary (State Payroll 2009).

<sup>2</sup> *Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions*, Lawrence Berkeley National Laboratories, 2009, page 1

## Total Anticipated Savings

Savings will vary from year to year depending on the buildings chosen to be commissioned. The following estimate is based on our suggestion for the first year's CCx effort:

- Integrated Science Building = \$132,882/yr  
(based on 16% of FY11 Costs = \$830,511)
- Studio Arts Building = \$12,187/yr  
(based on 16% of FY11 Costs = \$76,169)
- Recreation Center (160,191 gross sq.ft., built 2009) = \$26,122/yr  
(based on 16% of FY11 Costs = \$163,260)
- Polymer Science Building (198,612 gross sq.ft., built 1995) = \$81,409/yr  
(based on 16% of FY11 Costs = \$508,805)

**Total Anticipated Energy Cost Savings with Dedicated Team, First Year = \$253,398**

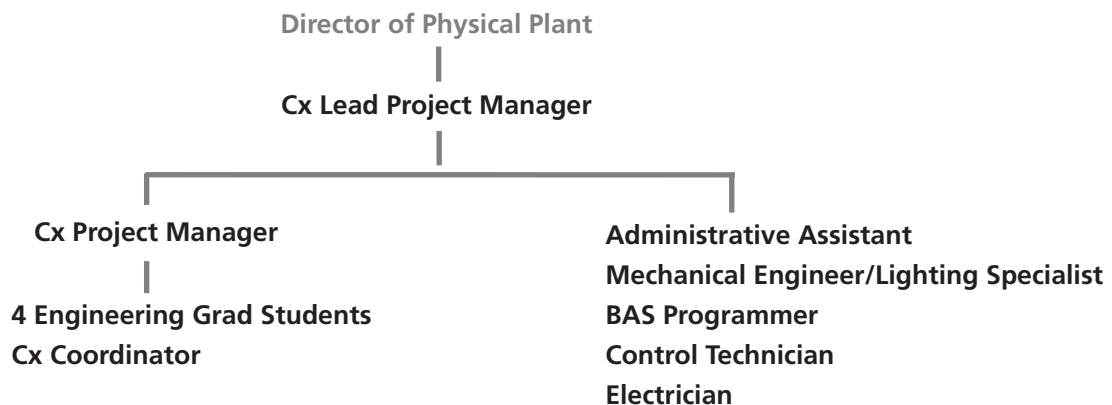
**Total Approximate Costs, First Year = \$564,053**

**Estimated Simple Payback Period is approximately 3 years.**

**Anticipated Savings by Year 5 of Continuous Commissioning Plan = \$1.1 million**

These savings will be continuous. Each year when buildings are continuously-commissioned the savings to the University will increase exponentially.

## Team Structure

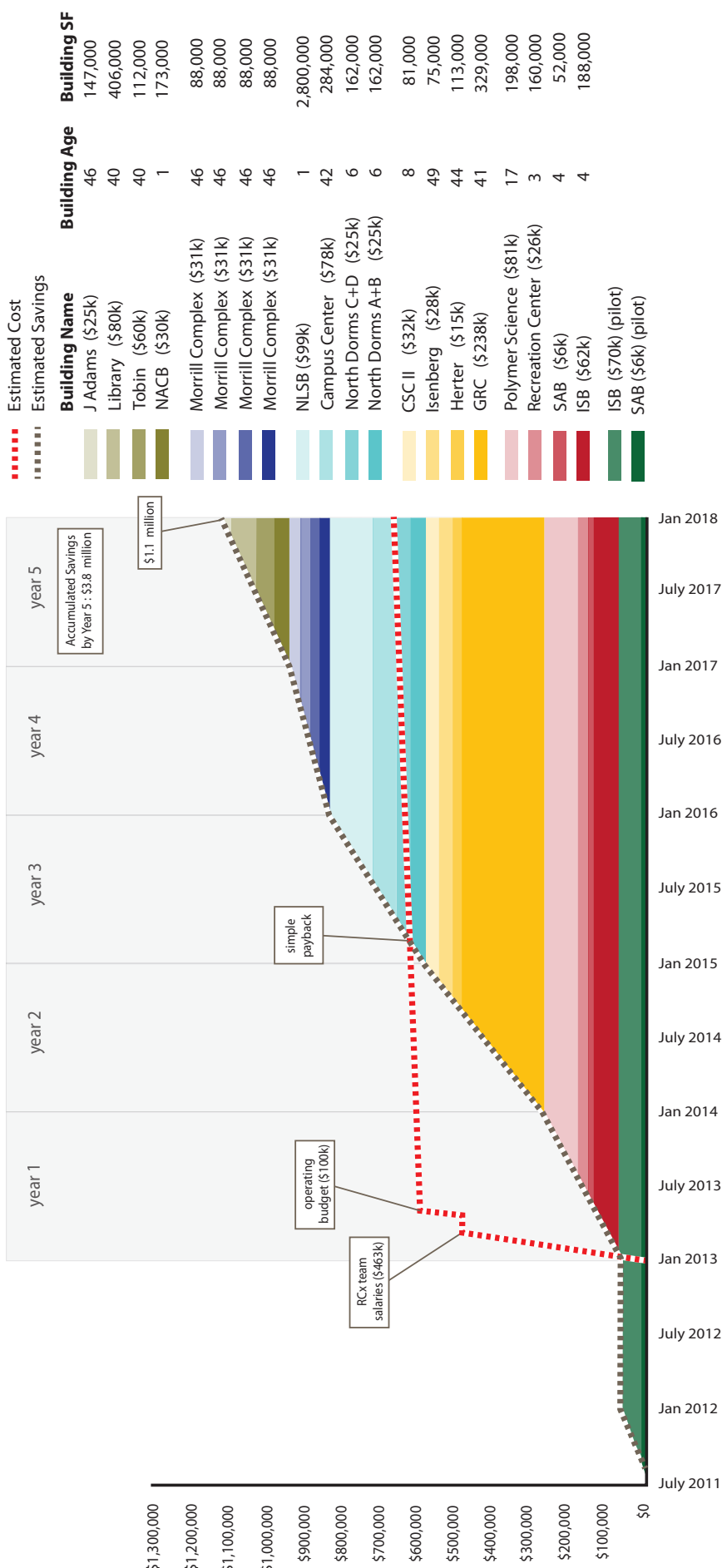


*When you hire outside resources to retro or new commission a building, when the outside resource has completed their work, the minute they walk out the door, they take with them the institutional intelligence that was developed.*

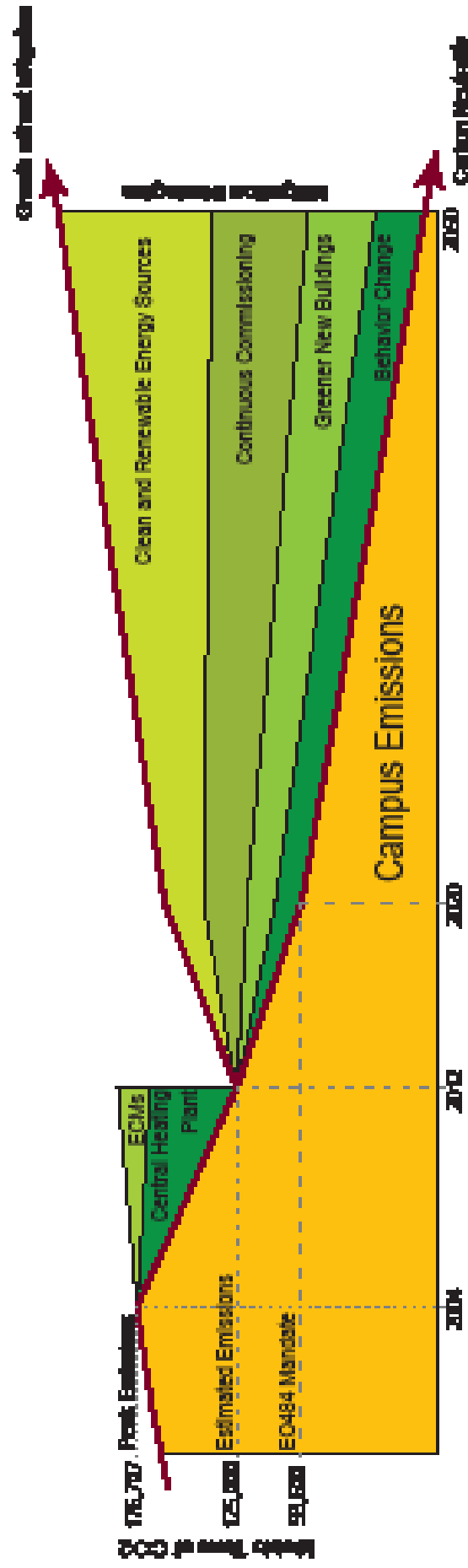
- Jerome Malmquist, Director of Energy Management, University of Minnesota



Anticipated Energy Cost Savings Years 1-5: UMass Amherst Continuous-Commissioning Proposal\*



\* Estimated savings are based on the Lawrence Berkeley National Laboratory 2009 Report on Retro-Commissioning, which found a 16% median energy cost savings for retro-commissioning of existing buildings.



Continuous commissioning is an important piece of the emissions reduction puzzle.

Estimated avoided emissions year 5: 13,146 metric tons CO2

Avoided emissions year 5 as percentage of total projected 2017: 21%



### Continuous Commissioning Team Task List

The pilot team created a list of the necessary tasks for each building to be retro-commissioned. A more in-depth task list and systematic plan would be written by the continuous commissioning team during the first six months of the project.

#### A. Research Existing Conditions

1. Assemble the following building information:
  - a. Room numbers & names
  - b. Room function
  - c. Contact person
  - d. Square footage & volume
  - e. Ventilation rates (cfm) from construction drawings
  - f. Occupancy schedule
  - g. Survey building automation system for operation parameters (ventilation and temperature set points)
  - h. Floor Plans and Operations Manual
2. Take a walk-through of building to verify floor plan and determine present room use
3. Determine schedules for classrooms, department office, etc.
4. Interview occupants about their experience in the building (heating, cooling, lighting, etc.) and/or distribute questionnaire
5. Interview building operators about their experience with the building
6. Survey equipment to assess proper operation (HVAC equipment and lighting controls).
  - a. Look for occupancy sensor problems
  - b. Test valves and dampers
  - c. Check system and terminal unit airflows
  - d. Determine fan and pump operation relative to design values
  - e. Document peak kw day/night, kwh/day weekday and weekend

#### B. Revisit "Owners Project Requirements"

7. Based on our survey of building occupants. write an Operations Plan describing:
  - a. Deliverable to building occupants: the range of temperatures, humidity, ventilation, and occupant control we allow in the building
  - b. Make note of the building's particular needs (humidity considerations for the bamboo cabinetry in the ISB for example)
  - c. Specify critical cooling requirements in specialty rooms such as freezer and electric rooms.
  - d. Relate our operations plan to the health, safety and conservation standards we wish to follow
  - e. Include descriptions and rankings of occupational hazards, and the displacement ventilation and special exhausts used to counteract those hazards. (this may involve contacting the engineer, industrial hygienist, and architect)
  - f. Identify variation between original design intent and present operating intent

### **C. Repair Existing Faults**

8. Consider differential pressure sensor calibration if it affects system assessment.
9. Maintain, calibrate, repair as needed systems (air handling and pumping systems)

### **D. Analyze Building's Performance**

10. Compare building energy budget to peers to further understand our building's performance
11. Apportion energy consumption to various end uses, electricity into lighting, plug, hvac air, pumping, air conditioning, misc process: steam into reheat, perimeter heat, domestic hot water.

### **E. Optimize Building's Operations to Meet Present Requirements**

12. Report chronology and track building performance over the RCx period.
13. Schedule unoccupied blocks of times
14. Look for optimization in sequences, setpoints, ventilation setpoints
15. Program changes
16. Conduct building operations review sessions with building maintenance staff and engineers as well as building occupants.

### **F. Create Building Operating Manual**

17. Note any operations changes post-RCx modification. (i.e. sound attenuator removal and snow melt addition)
18. Assemble documentation and describe new operating procedures.

### **G. Monitor Campus-wide Building Energy Data**

19. Be an information resource for the campus community.
20. Implement and maintain building equipment scheduling currently performed by JCI Performance Assurance Team.
21. Create building operating manuals for all buildings on campus.





## CCx at Other Universities

### University of Minnesota

Interview with Jim Green, Assistant Director of Energy Management, 9/21/11

#### Background

The program began 2004 with the ambitious goal of continuously-commissioning 40 buildings/year with 3 internal energy engineers and outside commissioning consultants. The University was very unhappy with the results after their first year, which was essentially “a long to-do list”. They decided to shift gears by being less ambitious about the number of buildings they would CCx in a year, do the bulk of the work with in-house staff (actually doing the work as they went along versus just identifying problems), and study their process as they worked.

#### Team Configuration & Pace of Work

They currently have 2 CCx teams which handle 12-15 buildings in a year. The goal is to CCx every building every 5 years. Each team is led by a Mechanical Engineer and various specialists are shared across the 2 teams. They have a Lighting Engineer, a Control Technician (poached from Johnson Controls), 4 Campus Engineers who each focus on a geographic region of the campus, and internal trades people such as a Balancer, 8 Electricians, 2 Sheet Metal Workers, and 2 Pipe Fitters. These teams will hire additional help when they need to. Compared to a traditional CCx team, the work of the Energy Management Department at UMN is more like that of an internal energy performance contracting group.

UMN's CCx talent is hired by the Capital Planning and Construction Departments to Cx new buildings. To creating a teaching experience from the project, they pair one Engineer with 1 student on each new building.

#### Keys to their Success

- Hired a very good Control Tech
- Designed ways to easily monitor the operations of their buildings so they can discuss these reports each week
- The Control System (Metasys - the same system UMass uses) is the domain of the Energy Management Department, and everything else is the domain of the district management
- “Step Zero” which occurs 2-3 months before CCx begins, involves inspecting the airhandlers very carefully to look for air leaks.
- Take meter readings every month and in fact hired a Technician to be responsible for this.
- Kick-off events at the beginning of each project where all occupants are invited to an informational ‘fair’ with food and tickets that get stamped if the building occupants has visited all the informational booths (on HVAC, lighting, the control system, etc.)
- Held meetings at end of project to review what happened.

#### Results

The energy savings is between 5-15% depending on the type of building.

*“Project costs range from less than \$100 to several \$100,000.”*

*“Our goal is to try and get to every building every five years. That being said, when we use our internal staff to do the commissioning of new or the retro-commissioning of old, they work with and use the building mechanics as much as possible. It then becomes a training program. When the building mechanics*

*understand WHY something is programmed a certain way, you have a much better chance of it being maintained that way. And then when people in the building want to make changes in the building, informed people are quicker to recognize what those changes might do to the building's comfort and energy profile without additional planning. When you hire outside resources to retro or new commission a building, when the outside resource has completed their work, the minute they walk out the door, they take with them the institutional intelligence that was developed. That is not smart!"*

- Jerome Malmquist, Director of Energy Management.

## University of Illinois

Interview with Karl Helmink, Retro-Commissioning Manager, Facilities & Services, 10/03/11

### Background

The program began 2007 with a team of 5 and a list of 5 buildings to retro-commission. They managed to accomplish their goal but had to increase the size of the team to do so. The team size is now 16 and they are able to retro-commission 6-8 buildings/year.

### Team Configuration & Pace of Work

One RCx Manager oversees 2 RCx teams. Each Team Leader is an experienced Engineer, and has a dedicated Controls Systems Integration Specialist, an Electrician, with DDC programming skills, Sheet Metal Specialist, Pipefitter & Steamfitter. There is also a dedicated Temperature Control Manager.

They do not yet have a set cycle period to revisit buildings that have been retro-commissioned. The goal is to cycle back every 8 years.

### Keys to their Success

- The RCx team has a narrow focus. Its does not include lighting retrofits for example, or having to manage the BAS data being collected. They focus much of their efforts on scheduling air handler units and connecting occupancy sensors to VAV boxes.
- They have been able to make significant changes to the air handling schedules of buildings such as eliminating 24hr occupancy. This information get communicated to the occupants and a student looking for a place to study at 2am has fewer choices.
- Rely on building coordinators to be the liaison between the RCx team and the building occupants.
- Also rely on technology to communicate with building occupants. There are web-based graphics of temperature controls, for those interested.
- The campus employs 6-8 Engineers who handle the programming on the DDC controls.
- The campus employs a Mechanical Engineer who is dedicated to lighting.
- They worked with an ESCO for one of their science buildings.

### Results

They have spent roughly \$9 million on their RCx efforts, and have avoided about \$12 million in costs, thus saving \$3 million.

The typically payback on a RCx project is 2 years or less.



## Harvard

In 2011 Harvard University retro-commissioned its LISE building (Laboratory for Integrated Science and Engineering, built in 2006, 135,000 sq.ft.) and was able to find a yearly savings of \$520,000 and 800 MTCDE (metric tons of carbon tons equivalent.)

*"LISE is the second largest GHG emitter on the FAS campus in terms of absolute emissions and third highest in terms of its GHG intensity by sf. It was therefore paramount to optimize its operations."* (<http://green.harvard.edu/lise-retro-commissioning-520k-annual-savings-and-800-mtcde-reduced>)

Jason Hehlo, the Faculty of Arts and Science Energy Manager led this project and was able to achieve these savings by implements the following measures:

- Various existing building systems that serve a common 9,600 Sq. Ft. clean room [dust-free environment for microlithography and nanofabrication], were combined into a more "closed loop" controlled feedback approach.
- The building automation system (BAS) was optimized to share common data amongst the systems. The BAS software references both the ever changing outside air dew point and the space conditions and their associated requirements. Simultaneous heating and cooling is now prevented, which in turn helped humidity and overall control of the clean room itself.
- Additional energy consumption was reduced by sharing key data between the recirculation air handling units and primary air handling systems. This data allows the systems to anticipate and react to the outside air conditions (outside air dew point temperature) while more accurately maintaining the space conditions.
- Total air changes to the space were reduced by carefully maintaining a slightly positive pressure within the clean room. This allowed the primary air and exhaust air duct pressure to be reset accordingly to the pressure changes within the space served. Many "blast gates" that were installed for future expansion were not being used and were now able to be closed. This changed the space differential and in turn, allowed the exhaust air systems and primary air handler system fans to ramp down in response.
- Discharge air temperatures were reset to as high as 70 deg F when outside air conditions permit (sensible cooling requirement only), pre-heating, pre-cooling, humidification and dehumidification cooling sections receive less of an overall load and provide an added energy savings benefit. This measure not only takes advantage of the many periods throughout the year where de-humidification is not needed and allows for a reduction in cooling/reheating energy, but also provides a system that maintains consistent space conditions and ultimately responds quickly to outdoor weather changes.

In Jason Hehlo's paper about Retro-Commissioning he states,

*"Commissioning is arguably the most cost effective strategy for reducing energy consumption, costs and greenhouse gas emissions in buildings today....Commissioning can sometimes be underutilized and not carried out to its fullest potential. Various reasons exist, however several contributing items are a lack of awareness, counterproductive competitiveness amongst trades, the absence of commissioning like requirements within building codes or contracts and insufficient professionalism. Unlike other "Green" measures or products, commissioning is often not visible to the building operators and occupants. Make the commissioning process visible to the building occupants. It is also important to maintain a balance between using and developing standards and recognizing that each building is unique and requires an open mind for a fresh approach."*

Scale of Impact

Realized savings of \$520,000 (FY10 dollars).

Realized reduction of 29,034 Ton-days and 498,154 kWh, 6,365 MMBtu over 800 MTCDE

## Continuous Commissioning Team Job Descriptions

### Job Title: Commissioning Lead Project Manager

Directs the UMass Continuous-commissioning Team in the commissioning of existing campus buildings, the handover of newly commissioned buildings to Physical Plant, and the commissioning of renovation projects. Responsible for defining safe, code compliant, and energy efficient operating procedures of commissioned buildings. Takes part in development of design guidelines and energy performance targets for new construction and renovations. Provides professional engineer's stamp to documents as required for building permits on work designed by this team.

#### *Minimum qualifications:*

Bachelor's degree in Mechanical Engineering. Advanced degree preferred.

7-10 years experience with building mechanical systems, including design and operation of energy management systems, heating, ventilating and air conditioning systems, and refrigeration systems. Advanced degree with related concentration can count towards experience.

Energy auditing experience, with track record of accurate performance prediction and implementation of effective conservation measures.

In depth knowledge HVAC testing and balancing procedures, and steam, water, and electric metering systems.

Registered professional engineer in Massachusetts.

Project management experience.

Communication skills.

### Job Title: Commissioning Project Manager

Manages continuous-commissioning projects, schedules team members in investigations, reports, and implementation work. Checks reports for accuracy. Assures effective communications with building users. Conducts training sessions with Physical Plant operating personnel.

#### *Minimum qualifications:*

Bachelor's degree in Engineering.

3-5 years experience in building system design, operation, or energy auditing. Advanced degree with related concentration can count towards experience.

Demonstrated energy auditing experience.

Energy modeling experience helpful.

Project management experience.

Communication skills.

### Job Title: Commissioning Mechanical Engineer

Investigates building system operation through field measurement and remote data acquisition and analysis. Communicates with building users about operating needs. Analyzes energy use patterns and correlates them with building operations. Builds energy models and calibrates them to actual energy use. Develops parameters for effective ongoing performance monitoring.

#### *Minimum qualifications:*

Bachelor's degree in engineering, or equivalent experience with a concentration in energy systems.

Knowledge of building systems, energy systems, computer analysis of engineering problems.



Ability to apply engineering knowledge to real life situations.

Desire to achieve energy conservation.

Good writing skills.

### **Job Title: Commissioning Building Automation System Programmer**

Develops working documentation of existing building automation system programming. Troubleshoots and corrects existing programs. Implements modifications to sequences of operation developed by the continuous-commissioning team. Creates automated monitoring systems to assess ongoing building performance.

#### *Minimum qualifications:*

Two year or 60 credit hour degree in HVAC, electronics, electrical engineering or mechanical engineering technology with demonstrated experience in computer programming, databases, network communications and electronic control systems.

Directly related work experience of four years or more can substitute for education requirements.

Familiarity with Metasys helpful.

### **Job Title: Commissioning Control Technician**

Investigates, troubleshoots and repairs existing HVAC control systems. Works with BAS programmer to implement system modifications, including hardware installation and programming of new or modified control systems. Takes part in monitoring and maintenance of newly commissioned systems.

#### *Minimum qualifications:*

Two year or 60 credit hour degree in HVAC, electronics, electrical engineering or mechanical engineering technology with demonstrated experience in HVAC control systems operation and maintenance.

Directly related work experience of four years or more can substitute for education requirements.

Familiarity with Metasys helpful.

### **Job Title: Commissioning Electrician**

Investigates, troubleshoots and repairs existing HVAC and lighting control systems. Installs HVAC and lighting controls. Takes part in monitoring and maintenance of newly commissioned systems.

#### *Minimum qualifications:*

Master electrician's license in Massachusetts.

Demonstrated experience with electronic controls for lighting and HVAC.

### **Job Title: Commissioning Staff Assistant**

Assists in preparation of commissioning reports, research of existing building documentation, filing and archiving of building documents, maintains contact list of building users and coordinates scheduling of building systems. Takes part in monitoring and maintenance of newly commissioned systems.

#### *Minimum qualifications:*

Two year degree in business or technical field, or equivalent experience in report writing and presentation development.

Computer skills in presentation software, spreadsheets, databases.

Communications skills.

## Example of Communications to Building Occupants

### THE GREEN BUILDING PROJECT AT THE STUDIO ARTS BUILDING

Your building has been chosen as a green building pilot project. We (the Green Building Committee) are attempting to certify the SAB under the LEED for Existing Buildings system. This work includes looking at the quality of the heating, cooling and ventilation in the building. To explain how you can control the temperatures of your studios, we have made this Thermostat Map.

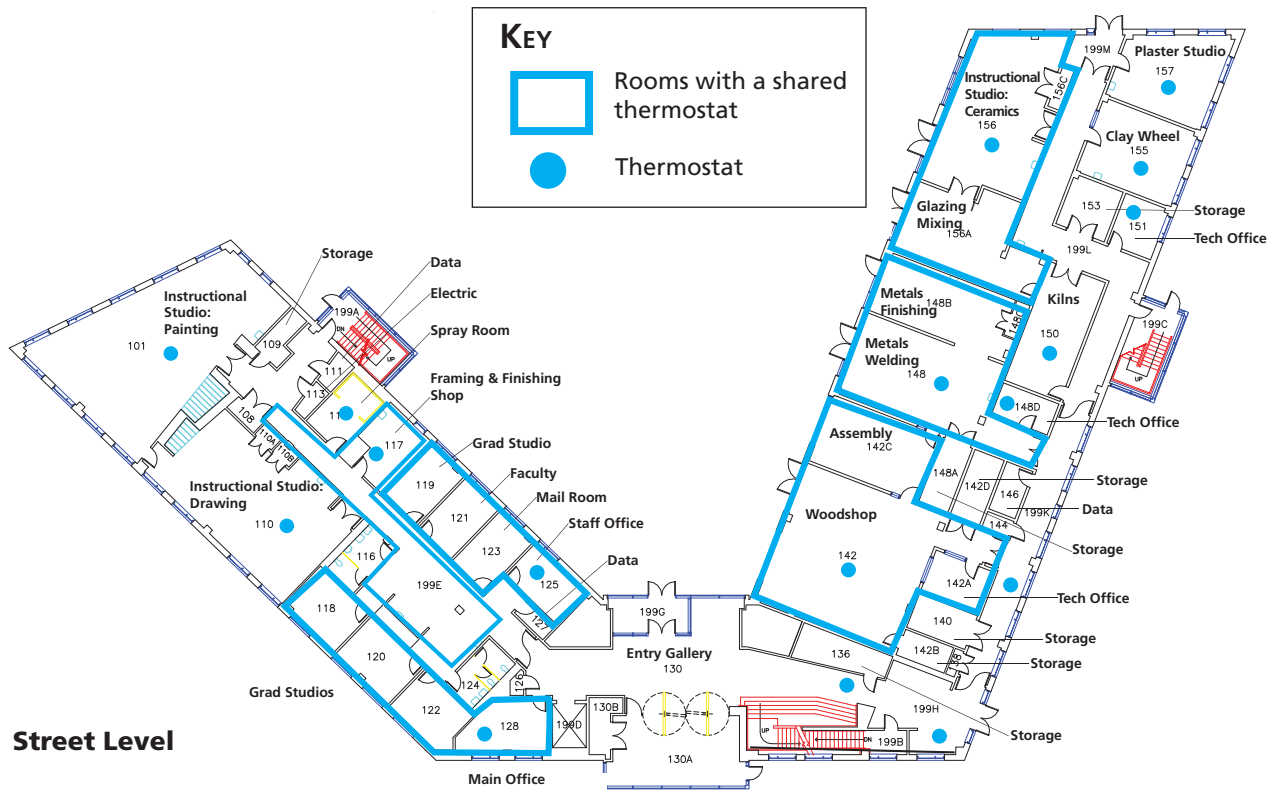
### THERMOSTATS IN THE STUDIO ARTS BUILDING

The thermostats in this building work! The temperature range, as presently programmed, is adjustable between 67–73°F.

To save energy each room has an occupancy sensor. When a room is not occupied the temperature can drop as low as 61° or as high as 82°. This is why rooms may feel too hot or too cold first thing in the morning, but once you're in the rooms the heating or cooling will kick in.

Most studios in the Studio Arts Building share a thermostat with a suite of other studios. The following map shows you where all the thermostats are located. If you have a studio containing the common thermostat, please coordinate with your "suite-mates." The occupancy sensors in each studio of a connected suite will activate the heating and cooling.

If the heating and cooling are obviously not working as they should, please contact Lisa Furtak, or Francis Merrigan.





GREEN BUILDING COMMITTEE  
ENVIRONMENTAL PERFORMANCE ADVISORY COMMITTEE  
UNIVERSITY OF MASSACHUSETTS AMHERST  
JULY 2012